①

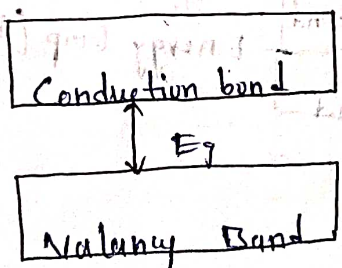
iii) Semiconductors :-

⇒ Semi Conductors are The basic materials used in The present Solid State devices like diode, transistors, LED's

⇒ In Semiconductors, there is a small band gap b/w The Valancy band and Conduction bond. energy gap is much Smaller than that of insulators

⇒ The bond gap decreases with increases in temperature (or) by adding impurities. When Band gap decreases electrons Jump into Conduction band Then Conductivity increases.

⇒ A Semiconductor is a material that has a conductivity b/w a good Conductor and insulator



(energy gap) (forbidden gap) [∵ Eg <3eV]

⇒ At very low temperature (0) a Semiconductor behaves as an insulator

⇒ Semiconductor have conductivity (10^{5} to 10^{-6} sm^{-1}) (or) resistance (10^{-5} to 10^{6} Ωm)

Types of Semiconductors :-

⇒ there are two types of Semiconductors

i) Intrinsic Semiconductors ii) Extrinsic Semiconductors

i) Intrinsic Semiconductors :-

⇒ These Semiconductors are pure form of Semiconductors

Example :- Si & Ge

⇒ Both these materials are tetravalent i.e. each they four valance e^-s in the outermost cell.

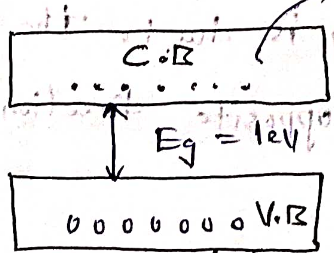
⇒ Energy gap is small for Si & Ge at 0K [Absolute zero]

Si (E_g) = 1.21 eV

Ge (E_g) = 0.785 eV

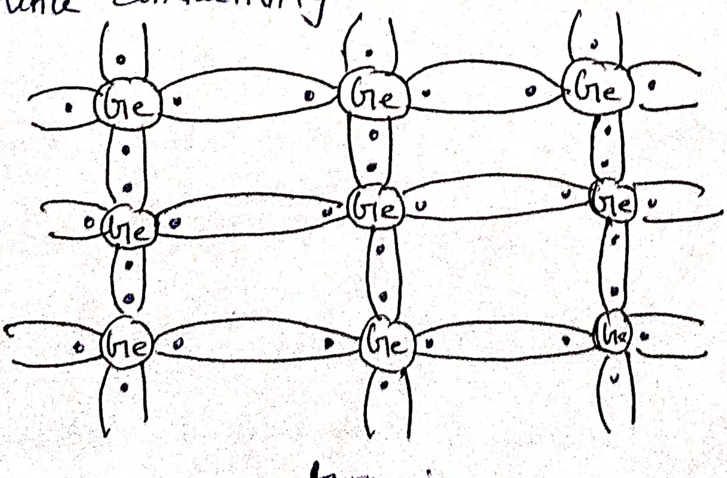
⇒ At room temperature some e^-'s in valancy band moved to conduction bond due to thermal energy.

e^-s moved to conduction bond.



holes formed due to transport of e^-s into Conduction Bond.

⇒ In this type of Semiconductor, no. of available charge carriers is less, hence Conductivity is Low.



Germanium.

⇒ Germanium has 32 electrons and silicon has 14 electrons in their atomic Structure. Since each of them have 4 valance electrons, they are tetra-valent atoms. The neighbouring atoms form covalent bonds by sharing 4 electrons with each other, this electron pair is shown in figure.

⇒ The energy required to break such a covelent bond is about 0.72eV for germanium and 1.1eV for silicon. At room temperature thermal Energy is sufficiant to break covalent bonds.

⇒ When covelent is broken an electron escape to the Conduction bond leaving behind an empty site in the valance band called a hole. It is relatively easy for valence electron in a neighbouring atom to leave its covelent bond to fill this hole thereby leaving a hole in its initial position.

⇒ Thus the hole effectively moves in the direction opposite to that of the e^-s hence the conduction of electricity is due to the motion of free electrons in one direction and holes in the opposite direction.

ii) Extrinsic Semiconductor :-

⇒ The electrical conductivity of pure Germanium (or) silicon can be increased by adding impurity in the process of crystallization. The added impurity is very small [1 Atom / 1 million atoms].

⇒ The added impurity may be pentavalent (or) trivalent elements

pentavalent : As, Sb (Antimony), ~~phosphorus~~ [P] [phosphorus]

trivalent : Boron, Al, Gallium, In,

⇒ Depending on the type of impurity added. The extrinsic semiconductor can be divided in two types,

i) N-type Semiconductors

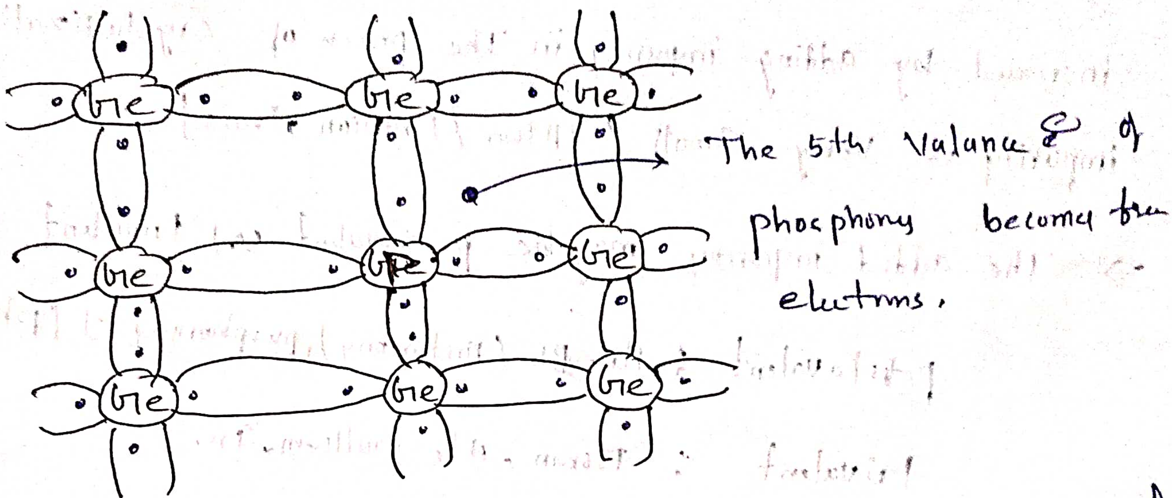
ii) P-type Semiconductors

i) N-type Semiconductors :-

⇒ When a small amount of pentavalent impurity [Phosphorus, Arsenic, Sb] is added to pure semiconductor. The resulting semiconductor is called N-type semiconductor.

⇒ When si (or) Ge is doped with pentavalent elements (P, As, Sb) They They occupy valance e's of si (or) Ge, The 5th e not used in bonding it is considered as extra electron (or) free electron. This electron increases the conduction in N-type semiconductor.

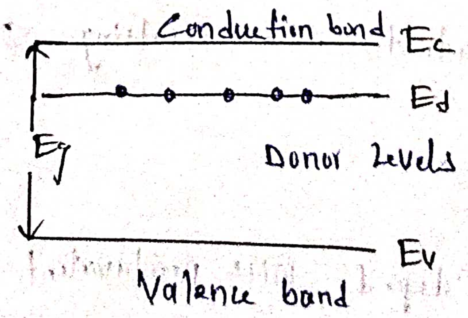
⇒ In N-type Semiconductor majority Carriers are electrons and holes are minority Carriers electrons are Negatively Charged The Extrinsic Semiconductor is called 'N-type Semiconductor.



⇒ A small quantity of pentavalent impurity is added to The crystal Then large number of electrons is produced in conduction band. Due to Thermal agitation some electrons in Valance band are shifted into The Conduction band by creating The holes in The Valance band.

⇒ The impurity atom is donating an electron to conduction band so this impurity is known as donar impurity.

⇒ The fermi energy Level is shifted towards The conduction band.



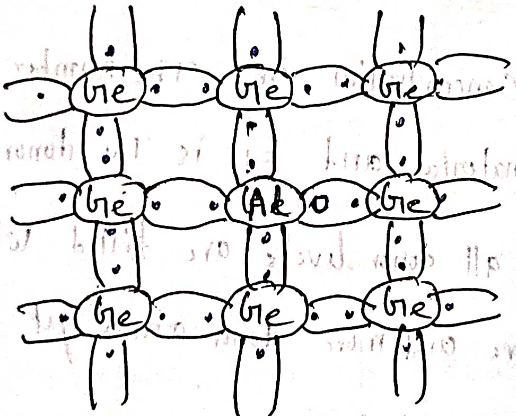
⇒ Germanium 0.01 eV, Silicon = 0.05 eV

*iii) P-type entrinsic Semiconductor :-

⇒ This Semiconductor is generated by dopping trivalent impurity to The intrinsic Semiconductor.

⇒ If an 'Al' atom is substituted in place of 'Ge' atom then it will Complete 3 Covelent bonds with three neighbouring 'Ge' atoms. But one more electron should be required to Compleate The fourth Covelent bond. In The absence of fourth electron a hole is generated which lies in Valance band. In this proces no electron is shifted to The Conduction bond.

⇒



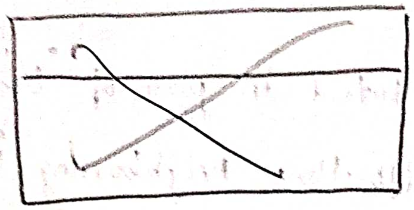
⇒ A Small quality trivalent impurity is added to The crystal Then Large number of holes in Valance bond. Due to thermal Agitation Some more electrons in Valance bond are shifted to Conduction bond by creating The holes in Valance bond.

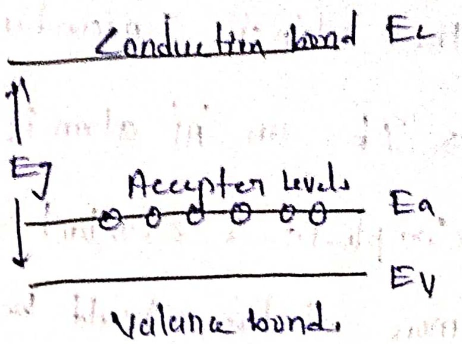
⇒ The impurity atom is in a position to get an electron so this impuring atom is known as acceptor impurity

⇒ In this Semiconductor majority carriers are holes and minority carriers are electrons. [hole → +ve , e^- → -ve]

⇒ The majority carriers are have +ve charge. So this semiconductor is known as p-type extrinsic semiconductor.

⇒ The Fermi energy level shifted towards the valence band.





* Carrier Concentration ~~of~~ In N-type Semiconductor :-

⇒ N_d is the donor concentration i.e. the number of donor atoms per unit volume of the material and E_d is the donor energy level.

At very low temperature all donor levels are filled with electrons with increase of temperature more and more donor atoms get ionized and density of electrons in the conduction band increases.

Density of electrons in conduction band is given by

$$n = 2\left[\frac{2\pi m_e^* kT}{h^2}\right]^{3/2} e^{\left(\frac{E_F - E_C}{kT}\right)} \quad \text{——} (1)$$

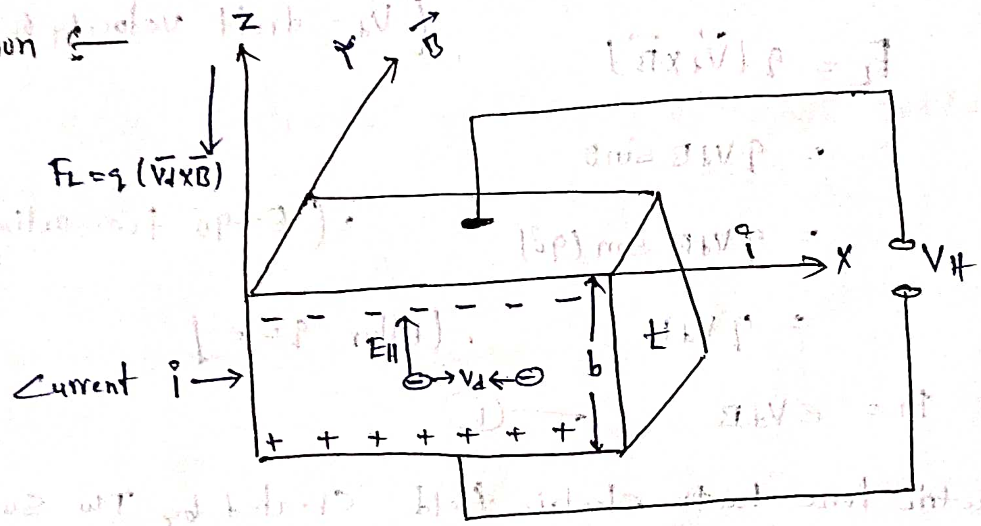
if we assume that E_F lies more than a few kT above the donor level then the density of ionized donors is given by $(E_F >> kT)$

$$N_d\left[1 - F(E_d)\right] \simeq N_d\, e^{\left(\frac{E_d - E_F}{kT}\right)} \quad \text{——} (2)$$

Hall EFFECT :-

⇒ When magnetic field is applied perpendicular to a current carrying conductor [metal or semiconductor] then a voltage is developed in the material perpendicular to both magnetic field and current in the conductor. this effect is known as hall effect The votage is developed is known as Hall voltage (V_H)

Explanation :-



⇒ Consider a rectangular block of Entrinsic Semiconductor. Let a current 'i' is passed in the conductor along X – direction and Magnetic field ($\vec{B}$) is established along Y - direction then charge carriers experiance Lorentz force (F_L) along the Z - direction. The direction of this force is noted by fleming left hand rule. As a result force (downward). The charge carriers are forced down in to the bottom surface.

⇒ If the speciman is a p-type semiconductor. Since the holes are the charge carriers, they are forced down into the bottom surface and hence the upper surface is occupied by the electrons; therefore potential difference is developed b/w the upper and lower surface.

⇒ this hall potential V_H can be measured by connecting two surfaces to a voltmeter

⇒ this separation of charge carriers creates an electric field (E_H) in the upward direction (+ve direction)

⇒ these charge carriers are moving in the magnetic field in the semiconductor they experience Lorentz force

$$F_L = q(\vec{V_d} \times \vec{B}) \quad (V_d = \text{drift velocity of the carriers})$$

$$= qV_dB \sin\theta$$

$$= qV_dB \sin(90) \quad (\theta = 90^\circ \text{ Force acting } \perp r)$$

$$= qV_dB \quad (\text{where } q = e)$$

$$F_L = eV_dB \quad \text{—— } (1)$$

⇒ The electric force due to electric field created by the surface charges

$$F = qE \quad (\text{where } q = e)$$

$$F = eE_H \quad \text{—— } (2)$$

E_H = is the hall electric field.

⇒ After some time both the forces becomes in the equal in magnitude and act in opposite direction the situation is said to be under equillibrium.

(1) = (2)

$$\cancel{e}E_H = \cancel{e}V_dB$$

$$E_H = V_dB \quad \text{—— } (3)$$

⑥

⇒ if J is The Current density then

$$J = ne V_d .$$

Where n is The concentration of current carrier's

$$V_d = \frac{J}{ne} .$$

V_d value substitute in Equation ③

$$E_H = \frac{BJ}{ne} \quad \text{—— ④}$$

⇒ The hall effect is described by means of The hall coefficient R_H

$$R_H = \frac{1}{ne}$$

R_H value in Equation ④ We get

$$E_H = R_H BJ$$

$$\boxed{R_H = \frac{E_H}{BJ} = \frac{1}{ne}} \quad \text{—— ⑤}$$

⇒ Since all The three quantity E_H, J and B are measurable, The hall coefficient R_H and hence The carrier density n can be found

⇒ Generally for N-type material since The hall field is developed in -ve direction compared to The field developed for a p-type material, -ve sign is used while denoting hall coefficient R_H

$$\boxed{R_H = \frac{-E_H}{BJ} = -1/ne}$$

⇒ For p-type material since The current is entirely by holes

$$\boxed{R_H = \frac{E_H}{BJ} = 1/pe}$$

Determination of The hall Coefficient :-

⇒ if 'b' is The width of Sample across which hall Voltage V_H is measured

$$E_H = \frac{V_H}{b}$$

$$\therefore \quad R_H = \frac{E_H}{BJ}$$

$$R_H = \frac{V_H}{BJb}$$

$$V_H = R_H BJb \quad \text{—— (6)}$$

⇒ if t is The thickness of The Sample, Then its cross section is bt and current density $J = I/bt$

J value in equation (6)

$$V_H = \frac{R_H BI\cancel{b}}{\cancel{b}t} = \frac{R_H BI}{t}$$

$$\boxed{\therefore \quad R_H = \frac{V_H t}{IB}}$$

Application of hall effect :-

i) It is used to find out whether The given Semiconductor is N-type (or) P-type.

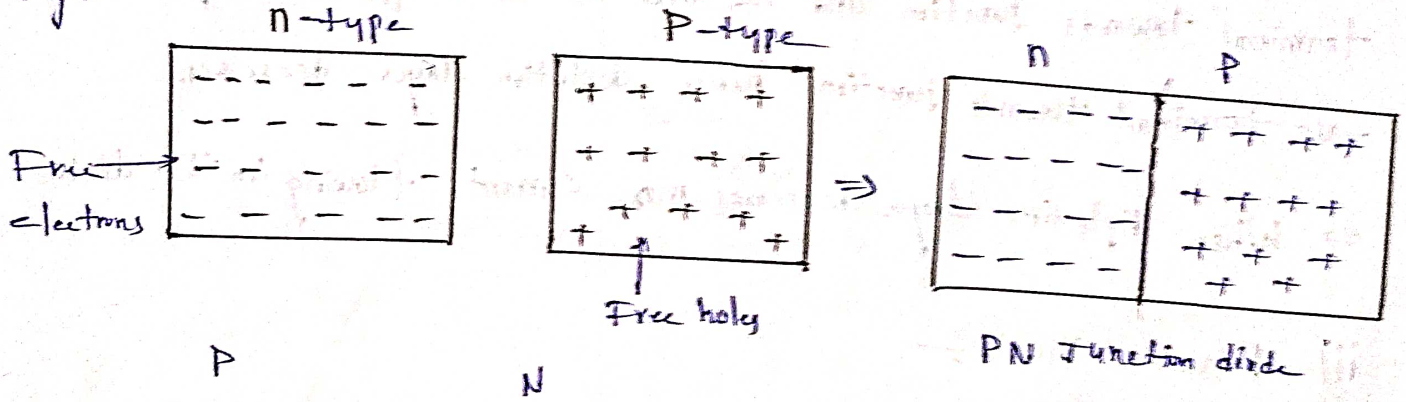
ii) It is used to measure carrier concentration, mobility and conductivity of Semiconductor material.

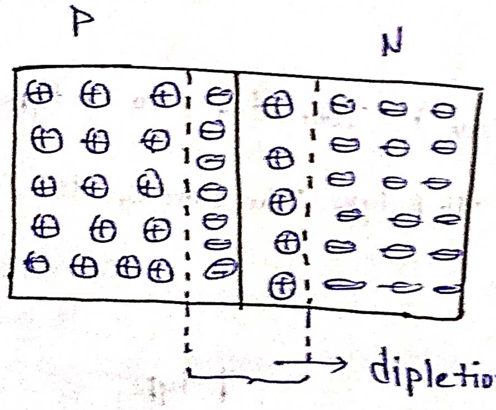
iii) hall voltage is produced of two input quantities namely The current and The magnetic field. Using this principle The hall effect device is used a multiplier.

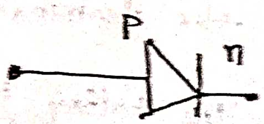
* P-N Junction Diode :-

⇒ A PN junction diode is formed from a piece of semiconductor by diffusing P-type material one half side and N-type material to other half side. The plane dividing two zones is known as Junction.

⇒ A P-type and N-type semiconductors before joining as shown in figur



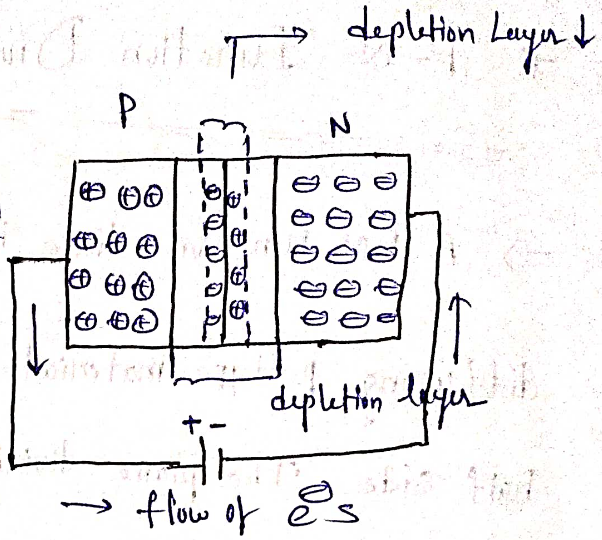




⇒ The above figure shows when P-type & n-type are joned together

⇒ Due to diffusion some $\bar{e}$ from N-region cross over to P-region where the holes from P-region cross over to N-region where they combine with electrons and becomes neutral. thus layer is formed which is known as Diplation layer.

i) Forward Bias :-



⇒ When +ve terminal of the battery is connected to p-type and -ve terminal connected to N-type semiconductor then the junction is called Forward biased as shown in figure

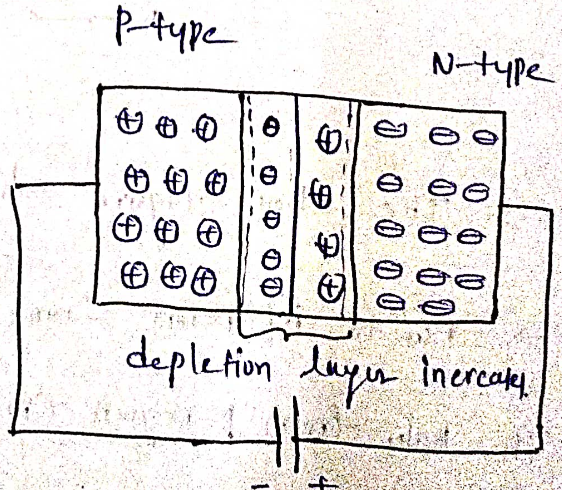
⇒ In forward bias holes from p-type are repelled by +ve battery terminal towards junction and the electrons in n-type are repelled by -ve terminal towards junction hence depletion layer decreases.

⇒ When depletion layer decreases more current flowing in the diode.

ii) Reverse Bias :-

→ When +ve terminal of the battery is connected to N-type and -ve terminal of the battery is connected to p-type the junction is called Reverse Bias as shown in figur.

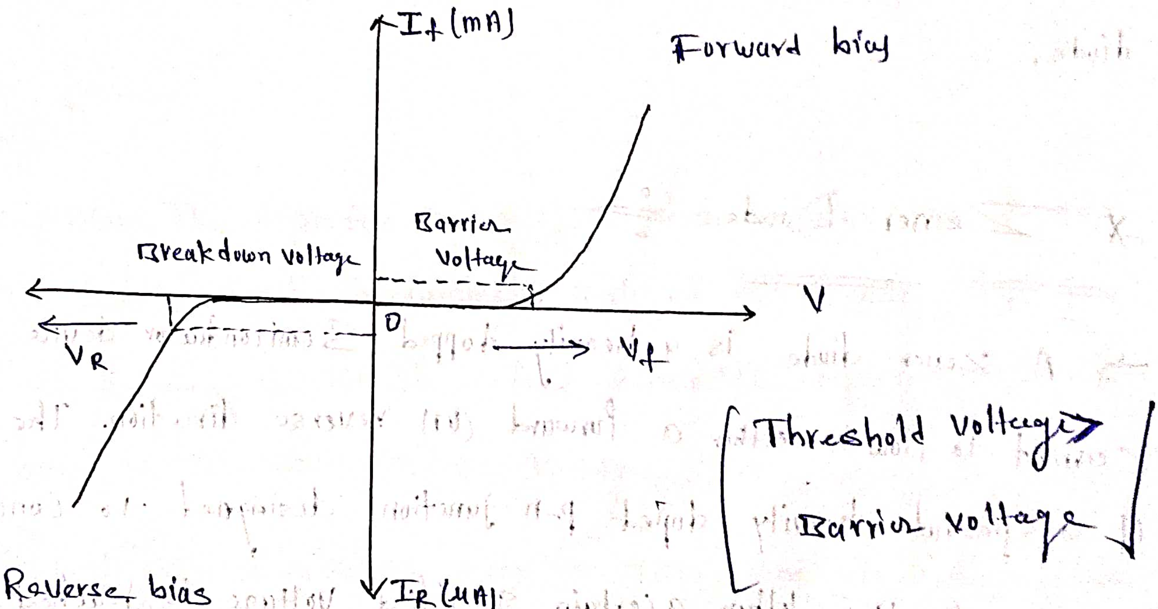
⇒ When +ve terminal of the battery is connected to N-type and -ve terminal of the battery is connected to P-type the junction is called reverse bias as shown in figur.



⇒ In Reverse bias the free electrons on N-type are attracted by +ve terminal of the battery & holes on p-type are attracted by -ve terminal of the battery hence the width of the depletion layer increases.

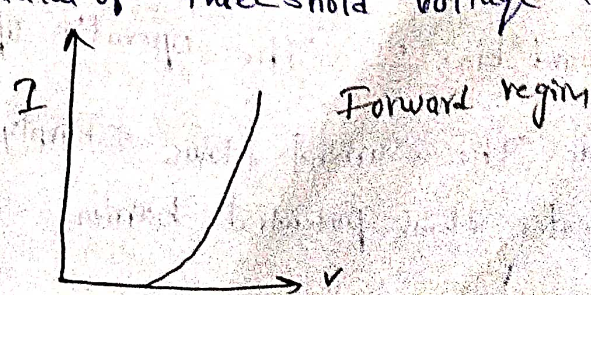
⇒ Due to thermal agitation a small current flows due to minority charge carriers.

VI Characteristics of P-N Junction diode :-



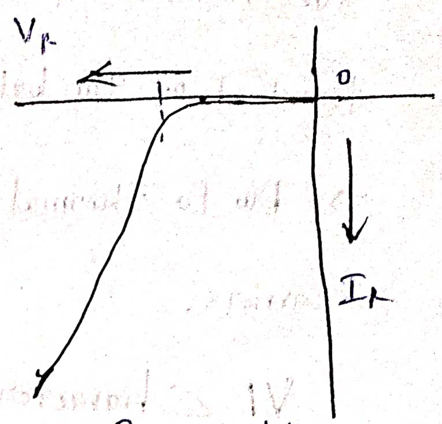
Forward bias :- The current in forward bias increases slowly with increase in applied voltage initially. The current in forward bias is less. The energy available to charge carrier is not sufficient hence current is zero.

⇒ After a certain Forward voltage current increases sharply in forward bias is called threshold voltage. The value of threshold voltage for Ge and Si 0.3 and 0.7



Reverse Bias :-

Grap Reverse Bias.



Reverse bias.

⇒ In Reverse bias initially The current is zero. As reverse Voltage increased current suddenly rises to its maximum (or) saturated value. If Reverse Voltage Further increased breakdown of The Junction occurs and a sudden rise of reverse current flowing in The diode.

* Zener Diode :-

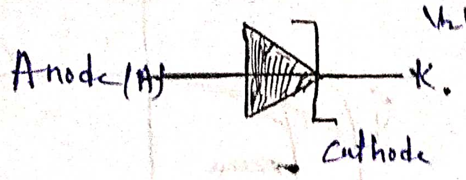
⇒ A zener diode is a heavily dopped semiconductor device that permits current to flow in either a forward (or) reverse direction. The diode consists of a special heavily doped p-n junction desingned to conduct in The reverse direction when a certain specified voltage is reached.

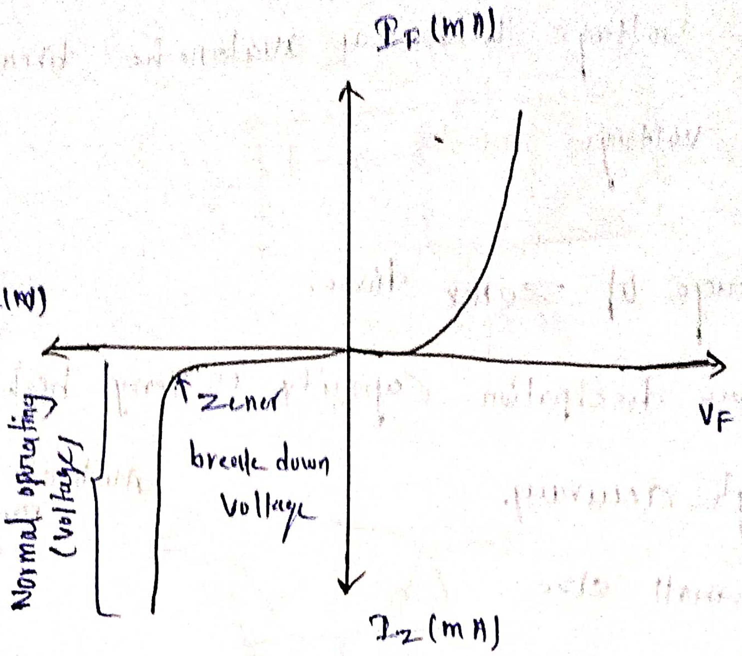
⇒ The zener diode has a well-defined reverse-breakdown voltages, at which it starts conducting current, and ~~continuous~~ operating continuously in The reverse-bias mode without getting damaged this feature makes zener diodes suitable for use in voltage regulation.

VI characteristics of Zener diode :-

Forward bias :- The operation of Zener diode is same as That of normal PN diode. The current flows sharply When The forward bias voltage is greater than potential barrier.

Zener diode Symbol.





Reverse bias :-

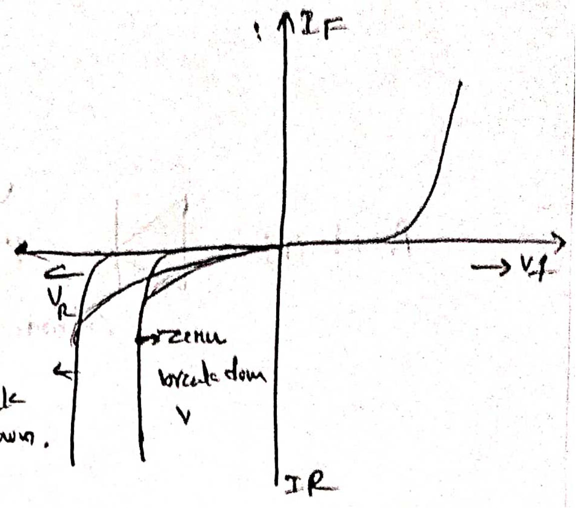
⇒ In Reverse bias The depletion region of The diode is very thin because it is made of The heavily doped Semiconductor material. The heavily dopping material increases The intensity of The electricfield across The depletion region of The Zener diode even for The small reverse Voltage.

⇒ this electric field pulls The electrons from The valancy band to conduction band by breaking The Covalent bond. When large number of such free electrons are available in Conduction band. it will Constitute large reverse Current this is called Zerner break down.

⇒ At zener break down a small increase in voltage will increase The electric current.

⇒ The zener break down voltage depends on The amount of doping. if The diode is heavily doped, Zener break down occurs at Low reverse voltage.

⇒ on The other hand if The diode is lightly doped, The zener break down occurs at high reverse voltage. Zener break down occurs at Low reverse voltage Where as avalanche break down occurs at high reverse voltage



Advantage of zener diode.

1. power dissipation capacity is very high
2. high accuracy.
3. Small size
4. Low cost

→ Avalanche break down occurs normal diodes

→ Avalanche break down occurs in lightly doped diodes.

Application of zener diode :-

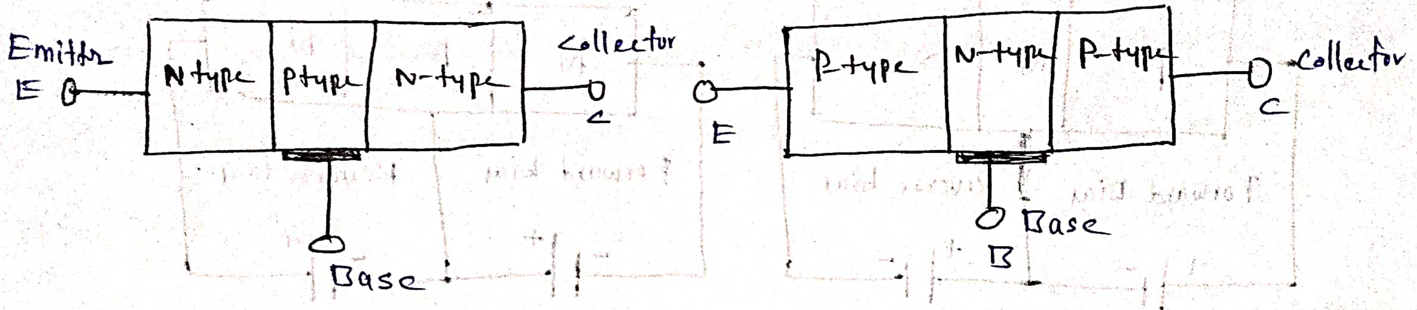
1. Voltage stabilizers (or) shunt regulators
2. Switching operations
3. Clipping and clamping circuits
4. Various protection circuits

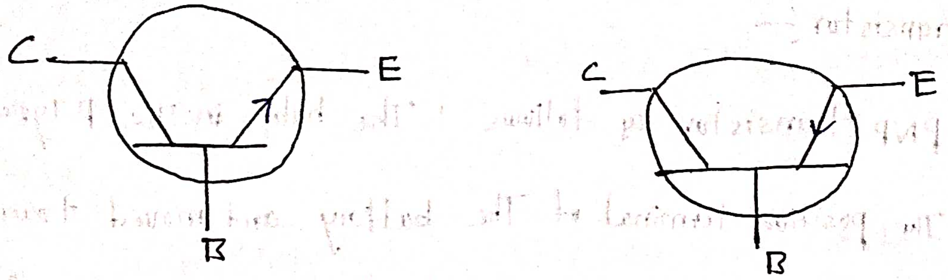
Bipolar Junction transistor [BJT] :

⇒ A bipolar junction transistor or BJT is a three terminal electronic device. Bipolar junction transistor (BJT) is a semiconductor device constructed with three doped semiconductor regions [Base, collector and Emitter] seperated by two P-N junctions. A junction transistor is simply a sandwich of one type of semiconductor b/w two layers of other type

There are two types of common types of junction transistors

1. PNP transistor : N type of semiconductor is sandwich b/w two P-type
2. NPN transistor : P-type of semiconductor is sandwich b/w two N-type





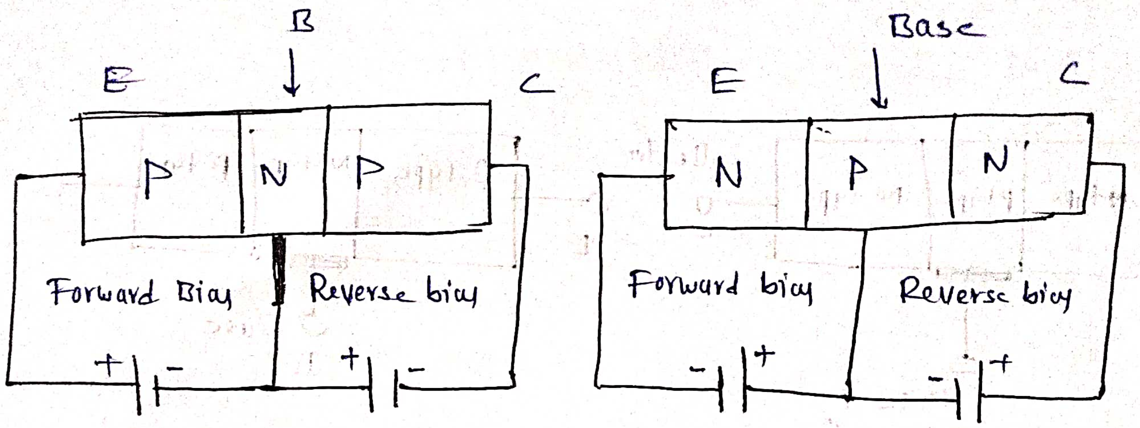
NPN- transistor PNP -transistor

Emitter :- it is The left hand Section (or) region of The transistor. The main function of this region is to supply majority charge carriers to The base and hence it is heavily doped.

Base :- This The Middle Section of The transistor. it is Very lightly doped and is very thin as compared to emitter and collector.

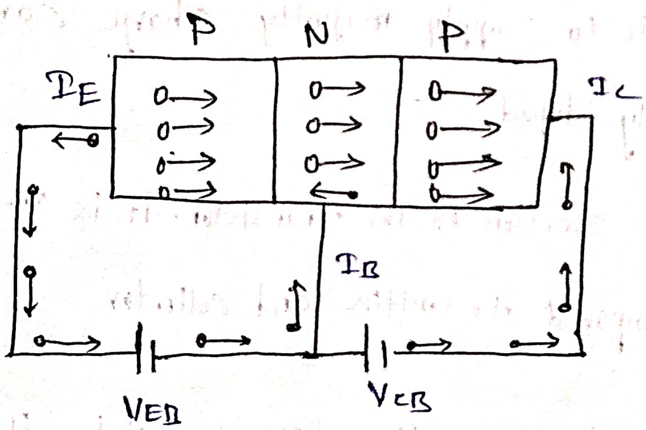
Collector :- this is The right hand Section of The transistor. its main function is to collect majority carrier's through base. this is moderatly doped.

Transistor Biasing :- The emitter base junction is always forward biased and Collector base junction is always reversed biased. The connection are as follows.



Operation of PNP transistor :-

⇒ The operation of PNP transistor as follows : The holes in the P-type Region are repelled by the positive terminal of the battery and moved toward the base. The potential barrier at the emitter junction is reduced as it forward biased and hence holes cross the junction and penetrate ~~for~~ to N region. this Constitute emitter current I_E



⇒ The width of The base is very thin and only few of the holes recombine with electrons 95% of holes are penetrated into Collector region because they are Swept because of reverse bias at Collector Junction; they Constitute Current I_C.

⇒ As hole reaches The collector, an electron is emitted from The negative terminal of The battery and neutralizes The hole.

⇒ Now covalent bond near the emitter electrode breaks down. The hole and electrons are liberated. The electron enters the positive terminal of the battery while holes moves towards the emitter junction. this process repeats again and again.

i. Current conduction within PNP transistor takes place holes conduction from emitter to collector. The conduction in the external circuit is carried by electrons

ii) The collector current is slightly less than emitter current as 5%. of holes are recombined by the electrons in the base

iii) The collector current is function of emitter current, if emitter increases. The collector current also increases

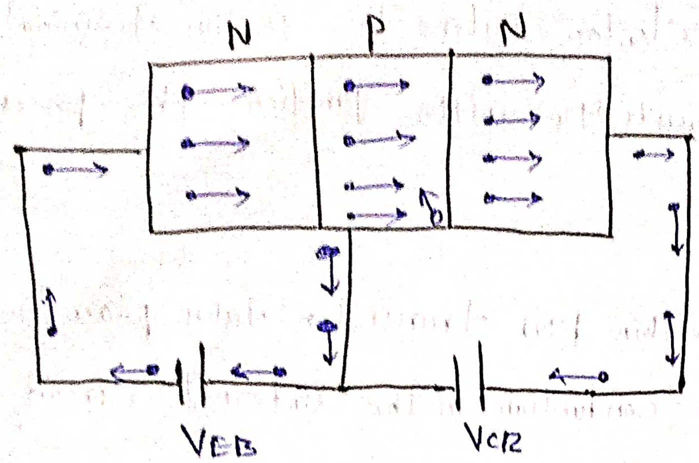
Holes play important role in the operation of PNP transistor.

Operation of NPN transistor :-

⇒ The electron in the emitter region are repelled from the -ve terminal of the battery and moves towards emitter junction. Since emitter junction is forward, base region is very thin and lightly doped electron crosses P-type base region.

⇒ In the base 5%. of electrons combine with holes remaining 95%. of $\bar{e}$s enter into collector. The electrons that entered are attracted by positive terminal of the battery. then electron from the negative emitter battery terminal enters the emitter region.

Electrons play important role in the operation of NPN transistor



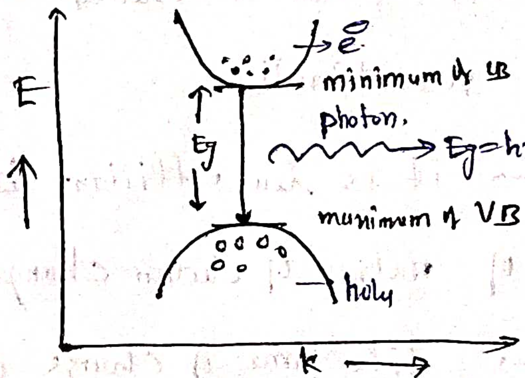
* Direct and indirect band Gap Semiconductors :- (12)

⇒ According to The band theory of solids, The energy spectrum of $\bar{e}$ Consists of large number of energy bands and are Seperated by forbidden regions. The band gap is The difference in The energy between The lowest point of Conduction band and highest point of Valence band

Based on The structure of energy bands, and type of energy emission Semiconductors are classified in two types

1. Direct band gap Semiconductor.

2. Indirect band gap Semiconductor.



1. Direct band gap Semiconductor.

→ The maximum of Valancy band and The minimum of Conduction exists at The same value of wave number (k) such Semiconductors are called direct band gap Semiconductors

→ In this type during The recombination of holes and electron, a photon of light is released. This process is known as radiative recombination. Also Called as spontaneous emission.

→ it is more effective, because The direction of motion of electron remains unchanged.

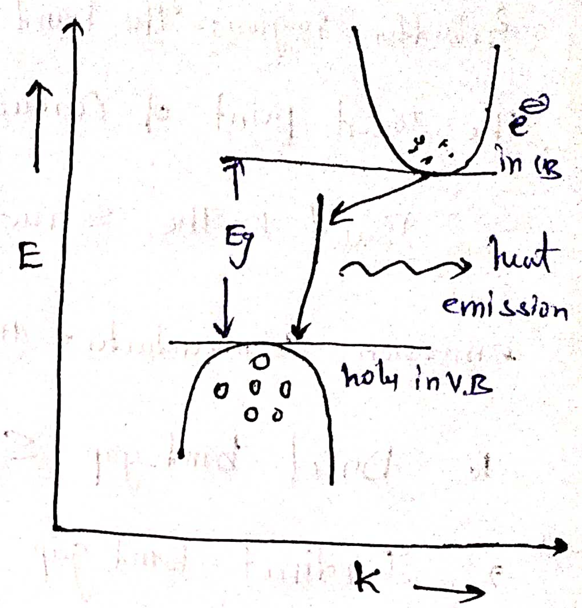
→ charge carrier is having very less time

→ these are used to fabricate LED's and laser diodes

→ Ex: InP, GaAs. ---

2. Indirect band Gap semiconductors.

→ The maximum of valance band and The minimum of Conduction band exists at The different values of Wave number (k). Such Semiconductor's are called Indirect band gap Semiconductors



→ In this type heat energy is produced during The recombination of holes and e⊖s this process is known as non-radiative recombination.

→ it is less efficiant because The direction of motion of electron changed

→ Life time of charge carrier's is very hight

→ Due to The longer life time of charge carrier's, these are used to amplify The signals as in The case of diodes and transistors

→ EX: Si (0.7eV), Ge (1.12eV) elemental semiconductors

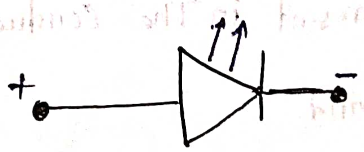
* LED [Light emitting diode] :-

Working principle of LED :- LED Work on The principle of Electroluminescence.

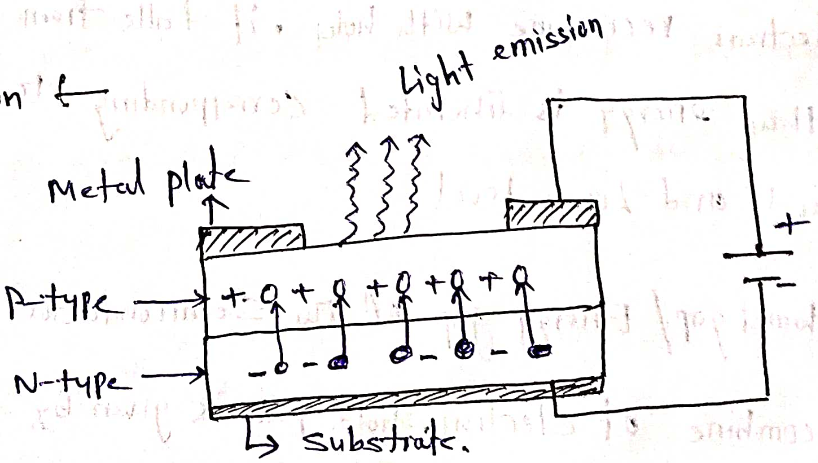
=> Light emitting diode is a optical diode, Which emits light When Forward biay

=> The Symbol of LED is similar to p-n Junction diode. Apart from two arrows indicating That device emits light energy.

Symbol of LED :-



Construction :-



=> One of The method is used for construction of LED is to deposit P-type and N-type layer on The Substrate

=> In between P-type and n-type their enist active region, this active region emits light. When an electron and hole recombine is forward biay.

=> Holes from p-type and electrons from n-type are get driven into The active region to emit light

⇒ LED emits light around the layered structure which is placed in tiny reflective cup. So that the light emitted from the active layer will be reflected in desired direction.

Basic operation :-

⇒ When ever a p-n junction diode is forward bias, the electrons crosses the p-n junction from the n-type semiconductors material and recombined with hole in the p-type semiconductor material.

⇒ The free electrons are present in the conduction band while the holes are present in the valancy band.

⇒ When free electrons recombine with holes, it falls from conduction band to valancy band. thus energy is liberated corresponding to the difference between higher level and lower level

⇒ if E_g is the band gap/ Energy gap of the semiconductor then the energy released due to recombine of electron-hole pair is given by.

$$E_g = h\nu$$

$$\boxed{E_g = \frac{hc}{\lambda}}$$

⇒ In normal diode energy is released in the form of heat, but in the LED energy is released in the form of radiation called light. energy this process is called "electroluminescence"

⇒ The energy released in the form of light depends on energy gap.

These determines The Wave Length of The Light emitted.

Materials :-

⇒ Gallium arsenide (GaAs) → emits Infrared.

⇒ Gallium arsenide phosphide (GaAsP) → emits red (or) yellow colour light

⇒ Gallium phosphide (GaP) → red (or) Green colour light

Advantages :-

→ its cost is verry Low.

→ it has long life time

→ they are available in different colours at Low cost

→ they can operate with Low Voltage. faster response $\simeq 10^{-9}$ sec

→ its intensity controlled easily & operate wide range temperature.

Disadvantages :-

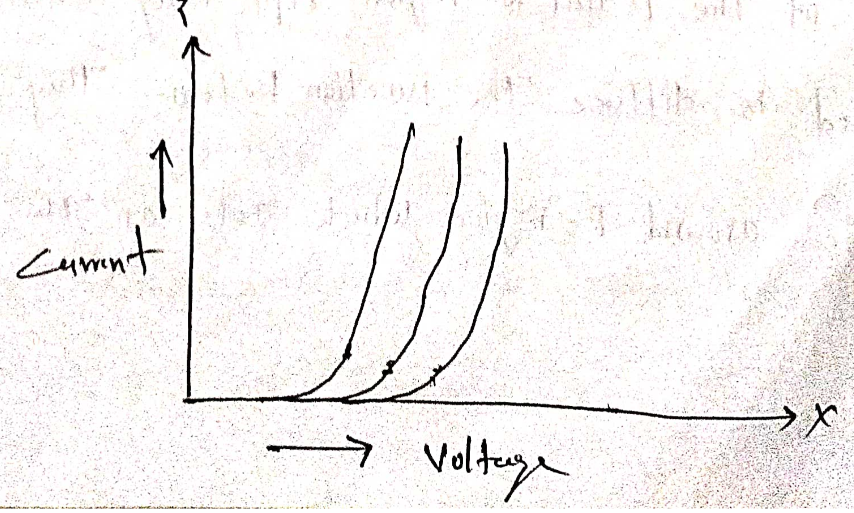
→ its out power is Low.

→ its Intensity is Less than Laser

→ its Light can not travell through langer distance

→ its light will not have directionality, incoherent & not in phase.

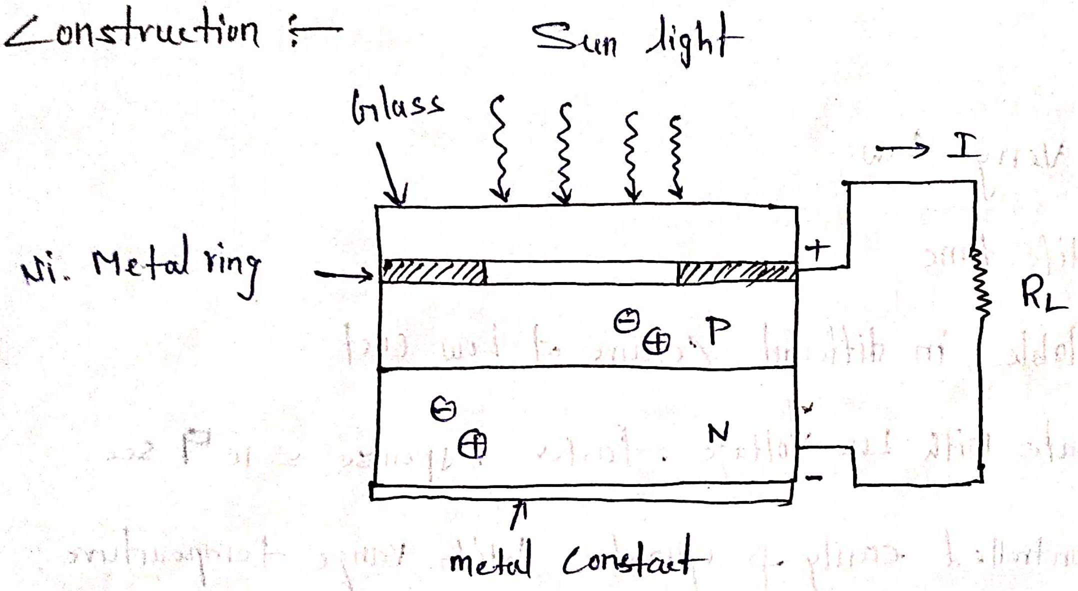
Graph :-



Solar cell :-

principle :- A solar cell is basically a photovoltaic cell. It converts the light energy to electrical energy and it is photo diode operated at zero bias voltage.

Construction :-



⇒ The construction of solar cell as shown in figur.

⇒ A solar cell consist of a P-N junction diode generally made of Germanium (or) silicon.

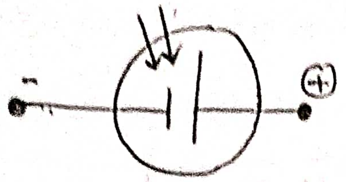
⇒ A Glass window in top of P-N junction so that light may fall upon P and N-type materials uniformly.

⇒ The thickness of the P and N-region kept very small so that electron and holes generated to diffuse the junction befoure they recombine

⇒ A Nickel plate around P-region which acts as the positive output terminals.

⇒ A metal contact at The bottom serves as The negative output terminal

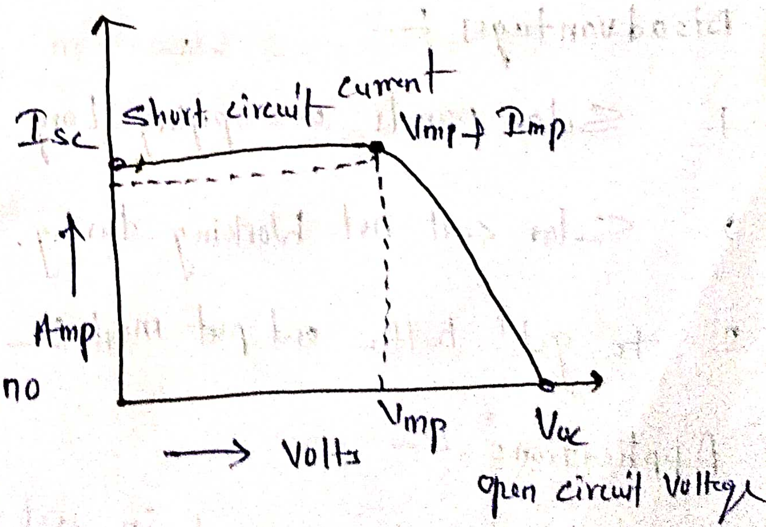
⇒ The Symbol of Solar cell as shown below figure



Working of Solar Cell :-

⇒ When light is allowed to incident on P-N junction diode photons colloid With Valency electrons then sufficient energy enabling them to leave their parent atoms. thus electron-hole are generated in both P-N sides of The junctions as shown in figure. then electrons and holes reach The depletion region. by diffussion hence current flowing in The circuit

VI Characteristics :-



⇒ The VI characteristics of a solar cell as shown in figure

⇒ When load resistance is infinate, no current flows through it and maximum voltage appears across The solar cell which is known as open circuit voltage Voc

⇒ IF $R_L = 0$ maximum current flow through solar cell which is called short circuit current Isc

⇒ $V_{oc} \times I_{sc}$ is Theritically The maximum power That Obtained

⇒ Experimentally The maximum power is $V_m I_m$

⇒ The fill factor of a Solar cell is defined as The ratio of experimentally maximum power to The ideal power

$$\boxed{\text{i.e. Fill factor} = \frac{V_m I_m}{V_{oc} I_{sc}}}$$

Advantages :-

1. Solar cells do not use any fuels
2. They are not dangerous
3. Solar cells do not pollute atmosphere
4. Solar cells do not produce noise

Disadvantages :-

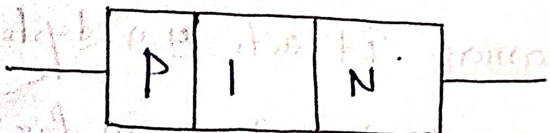
1. Solar panels occupying Large space
2. Solar cell not Working during night
3. to get better out-put must be cleaned regularly

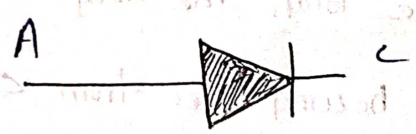
Applications :-

1. Solar cells are used in satellites and space Vehicles to supply power to electronic equipments
2. Solar system are used to power railway signals alarm systems and etc
3. Solarcells are used in T.V transmitters
4. Solar calculators, water heaters, Solar pump sets, Solar Lights, etc

PIN Diode :-

⇒ A diode obtained by Semdwiching pure material (i) between p-type and n-type entrinsic semiconductors is called a pin diode. The diode Consists of p-type and n-type heavily doped materials along With intrinsic material between them. The Constuction is shown in The fig. While its symbol is shown in The fig. The Symbol is similar to That of Conventional diode



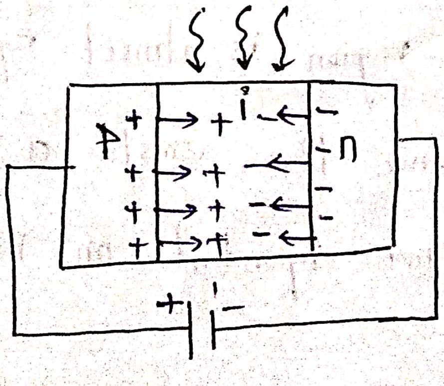


PIN diode

Working principle of pin diode :-

⇒ The PIN diode behaves differently in forward biased and reverse biased Conditions.

Forward biased operation :-



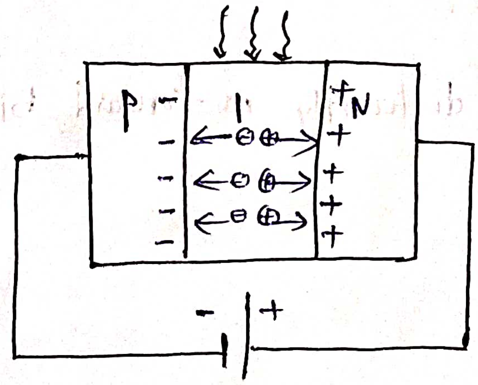
⇒ ~~In forward~~ bias, ~~The holes and electrons~~.

⇒ In forward bias. The holes from p-side and electrons from n-side are injected into i-region. this increases carrier concentration of i-region. this decreases the resistivity and increase conductivity modulation of PIN diode. this forward current flows due to both electrons and holes.

⇒ thus in forward biased condition, the PIN diode acts as a current controlled variable resistance.

Reverse biased operation :-

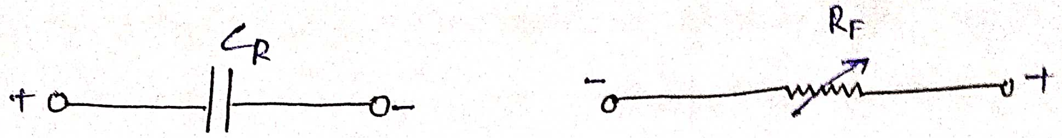
⇒ In reverse bias, the holes and electrons move in opposite directions and i region becomes free from charge carriers. It acts as a depletion region. and is called swept free i region which is shown in fig



⇒ The length of the depletion region is almost equal to length L of i region, which is constant. hence there exists a transition capacitance which remains constant and not dependent on reverse voltage.

⇒ thus in reverse biased condition, The PIN diode acts as a constant capacitance (CR)

⇒ The equivalent circuits of forward and reverse biased PIN diode are shown in fig.



(a) Reverse-biased   (b) Forward biased.

Characteristics of PIN diode:—

⇒ The forward series resistance characteristics are shown in fig. As shown in fig. The forward series resistance decreases as the forward current increases.

⇒ The reverse capacitance characteristics as shown in fig. ~~The~~ transition capacitance is almost constant with reverse voltage V_R.

Applications of PIN diode:—

The various application of PIN diode are

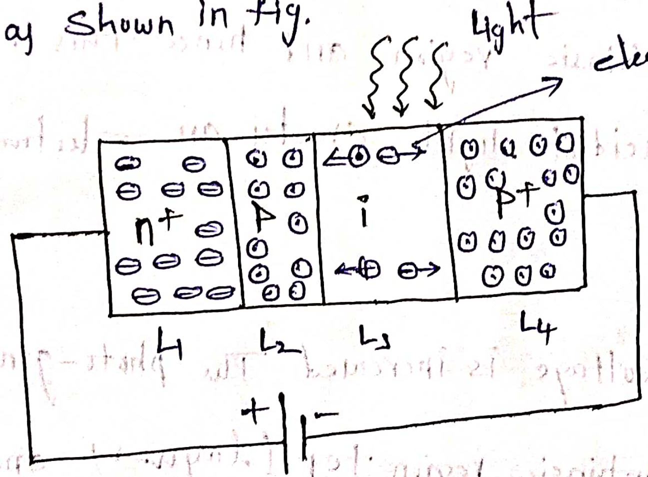
1. As a DC controlled microwave switch
2. Amplitube modulators at microwave frequencies
3. As a voltage variable attenuators in radio frequency circuits
4. As a phase shifter in phase array radar systems

APD [Avalanche photo Diode] :-

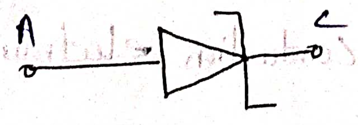
Principle :- The diode also works in reverse bias, under reverse bias when light is made to fall on the neutral (or) intrinsic region ; electron hole pairs are generated. By avalanche effect more number of electrons, hole pairs are created which results in Large photo-current than that of the PIN photo diode "The light energy converted into Electrical energy."

Construction :-

→ The Avalanche photo diode consists of four regions p^+, i, P and n^+ with necessary as shown in fig.



Symbol :-



→ The layer-1 consists of a heavily doped n-region. denoted by n^+ The layer-2 is made up of P region and layer-4 is heavily doped with the same p-region. denoted by p^+. The intrinsic region is lightly doped with the p-materials.

→ totally We can imagine The diode as p-n junction diode In which The p-region is composed of Three layer's P, i, p P+

Working :-

→ initially before The light incident on The diode a reverse bias voltage is applied. At certain voltage The depletion region gets widen Through both The I and P is lightly doped. The intrinsic region i gets more depleted because of its Larger Area this is called as depleted mode.

→ When The light from The optical fiber is made to fall over The diode The light observed by intrinsic region and hence this region is also called as collection region. The incident light creates an electron-hole pair in The intrinsic region.

→ Now When biasing voltage is increased The photo-generated electrons moves/drift through The intrinsic region top (layer-2) and n (layer-1) Junction. here they collide with free electrons in The Valance band and releases more number of free (or) Conduction electrons they avalanche effect is produced.

→ Since large current is produced even When a single photon incident on The diode these diodes are termed as highly Sensitive detector's

→ A reverse voltage continuosly increases at some point avalanche break down occurs. At this point, a small increase in voltage will suddenly increase in the current

Materials :- Germanium, Silicon & III - V components

Application of APD :-

1. Data transmission
2. Range finding
3. high speed industrial inspection
4. Distance Measurment
5. Various medical & scientific instruments

Disadvantages :-

1. Much higher operating voltage is required
2. The output is non-linear due to avalanche process
3. APd produces higher level of noise